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ABSTRACT

Two experiments were conducted to ascertain whether the reader uses phonological cues, semantic cues, or both types of cues in identifying letter combinations. Sixty introductory psychology students participated in the first experiment, which tested the differential effects of phonological and semantic cues on the speed with which a verbal unit can be identified. For the second experiment, 20 undergraduate students took part in two sessions to investigate the question of verbal meaning. When presented visually with a verbal item, the subject had to decide rapidly whether it was or was not a part of his vocabulary. The results of the two experiments indicated that both phonological and semantic cues had an influence on identification speed for verbal material. The most important implications for reading research were drawn from Experiment 2, since it appeared to be a better analog of what the reader does than those experimental tasks which have been used in former research. Use of the same methodology employed in these experiments with more complex materials was recommended for further research. Tables and references are included. (DH)

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Summary

Experiment I

The purpose of the first experiment was to determine if phonological cues and semantic cues have a differential effect on the speed with which a verbal unit can be identified dependent on whether the material had been stored in primary memory (PM) or in secondary memory (SM). The distinction between PM and SM has been discussed extensively by Waugh and Norman (1965) and Atkinson and Shiffrin (1968); and has been experimentally investigated by Stanners and Meunier (1969). An everyday example of the distinction would be that between looking up a telephone number for immediate use and then "forgetting" the number very quickly after dialing (PM) as compared to the type of memory used for much longer term storage, e.g., home addresses, wives' birthdays, etc. (SM). Three levels of material were used. One level (words) was comprised of units which were both phonologically and semantically intact, e.g., MOP; another level (E-Pr) was phonologically but not semantically intact, e.g., NOP; and a third level (D-Pr) was both phonologically and semantically anomalous, e.g., OPN.

The major results were: (a) Indentification from PM was much faster than identification from SM for all types of material. (b) The status of the item as a word had a much larger effect on identification speed when materials were in SM as compared to PM. Apparently, the semantic cue is much more important in the recognition of material in SM as compared to the recognition of material in PM.

Experiment II

The second experiment was an attempt to develop a rather direct method of investigating the very old question of verbal meaning. The experiment took the form of a task in which the subject (S) was presented visually with a verbal item and had to make a rapid decision on whether it was or was not part of his vocabulary. The technique capitalized on the impressive human ability to reject an item in a split second as not being a member of the vast set of units that comprises an average vocabulary.

The variables of the study were aspects of the phonological structure and whether or not the item had a semantic reference. Specifically, the materials were consonant-vowel-consonant (CVC) trigrams which had no semantic reference, e.g., BER; CVCs which were words but had exactly the same beginning and ending phonemes as the CVCs, e.g., BAR; and consonant-consonant-consonant (CCC) trigrams which had the same beginning and ending consonants as the CVCs and the words, e.g., BKR.

The major results were (a) CCCs could be rejected much faster than the comparable CVCs. (b) Words could be accepted much faster than phonologically matched CVCs could be rejected. (c) Within the

sets of CVCs and words, the frequency of occurrence in the language of the initial and final phoneme had an effect on the speed with which the item could be accepted or rejected.

Introduction

The proposed study was based on two contrasting views of reading. One position is represented by Gibson (1965). A central thesis of Gibson's research is that a critical stage in the reading process consists of encoding graphemic units (letters or letter combinations) into phonological or sound units. The assignment of semantic meaning to letter combinations is considered an additional stage in reading.

A strongly dissenting view is exemplified by the writings of Kolers (in press). Kolers' basic position is that the skilled reader identifies graphemic units entirely on the basis of semantic meaning and does not go through the intermediate stage of phonological encoding.

The general question which was considered by the research was whether the reader uses phonological cues, semantic cues, or possibly both types of cues in identifying letter combinations. The major new contribution made by the experiments was the development of two experimental analogs of reading which appear to come much closer to the task of the skilled reader than the tasks used by either Gibson or Kolers.

Both experiments indicated that phonological variables and semantic cues had a substantial effect on verbal identification speed. A general implication of the experiments would be that phonological variables would be of importance in the study of reading to the extent that verbal identification is involved in the reading process.

Method

Experiment I

The major question in Experiment I was whether identification speed in two levels of memory would be different for materials having phonological and semantic properties, phonological but not semantic properties, and for materials which had neither property.

Subjects - The Ss were 60 students enrolled in introductory psychology at Oklahoma State University. The Ss received a small credit toward their final course grade as an inducement to participate.

Materials - The materials were comprised of consonant-vowel-consonant words, easy-to-pronounce (E-Pr) CVC nonwords, and difficult-to-pronounce (D-Pr) units produced by permuting the letters of the E-Pr items. An example of a set of such items would be MOP, NOP, and OPN. There were eight items of each type used in the experiment.

Associated with each of the eight items in each category were six comparison items. Three of the comparison items had a letter changed in one position. For example, three of the comparison items for MOP were TOP, MAP, and MOB. The counterparts for NOP were ROP, NEP, and NOV; and for OPN, three comparison items were EPN, OVN, and OPR. The other three comparison items for each of the eight items in a category were identical to the category units themselves. Thus each of the three categories (words, E-Pr, D-Pr) had eight items and six comparison items associated with each of the eight.

Procedure - The S was seated at a small table attached to the back of which was a 30" X 36" plywood screen. A 12" X 12" translucent Plexiglas screen was mounted in the middle of the plywood screen at approximately eye level. Into the top of the table was built a toggle-type switch which could be held between S's thumb and forefinger when his arm was resting comfortably on the table.

The beginning of a trial was signalled by a buzzer which informed S that he was to attend to the Plexiglas screen. A few seconds after the buzzer a category item was projected onto the Plexiglas for a period of time determined in a pretesting session. The apparatus for the display of the materials consisted of two 35 mm. slide projectors equipped with solenoid-operated shutters and programmed by an 8-channel Layfayette timer. On one-half of the trials a comparison item followed the category item immediately. The S was instructed to move the switch one way if the comparison item was the same as the category item and to move it in the opposite direction if the comparison item was different. The reaction time (RT) from the onset of the comparison stimulus until S moved the switch was recorded to the nearest millisecond (msec.). On the other one-half of the trials a randomly selected 3-digit number followed the category item. The S was instructed to count backwards from the number by threes in time with a pacing light which flashed at a .75 sec. rate. The backward counting continued for a 10-sec. period and was followed by the comparison item. The S then made a switch movement indicating whether the comparison item was the same as or different from the category item. RT was recorded from the onset of the comparison item until the S's response. The purpose of the 10 seconds of backward counting, which is quite a demanding task (Peterson and Peterson, 1959), was to insure that the category item was not in PM at the time the comparison item was presented.

A pretesting period which preceded the main part of the task was used to determine a presentation interval for the category items. Items of the same type as the category items were presented for durations which were varied by the experimenter until a duration was found such that the S could recall five out of six items after a 10-sec. period of backward counting. This procedure made it much more likely that the comparison stimulus actually did get stored in SM during the trials of the experiment proper.

Immediate (PM) vs delay trials (SM) was manipulated within-Ss with 24 trials of each type which were evenly but unsystematically distributed over the complete experimental session. On one-half of the immediate trials the comparison item was the same as the category

item and on the other one-half, the comparison item was different. The same arrangement held for the delayed trials. Counterbalancing between Ss insured that immediate and delay trials occurred equally often with each item and that switch movements to the left and to the right occurred an equal number of times for same and different comparison items.

The type of category (word, E-Pr, or D-Pr) was manipulated between-Ss with 20 randomly selected students assigned to each condition.

Results and discussion - The score for a given individual is the mean of 12RTs which comprise the measurements in a single subcondition. The means of scores over the 20 Ss in all subconditions are presented in Table 1. The scores were also analyzed by means of a 3-factor analysis of variance. Category (Word, E-Pr, D-Pr) was a between-Ss factor and Comparison Interval (Immediate, Delay) and Comparison Type (Same, Different) were within-Ss factors. The .05 level was adopted as the minimum level at which a term would be considered statistically significant.

The significant main effects were Comparison Interval, $F(1,57) = 183.54$, $p < .001$, and Comparison Type, $F(1,57) = 37.77$, $p < .001$. One significant interaction term was Comparison Interval by Comparison Type, $F(1, 57) = 131.00$, $p < .001$. As is evident from Table 1, the difference between average reaction times for "Same" and "Different" was much larger when the comparison stimulus was presented immediately than when the comparison stimulus was delayed for 10 seconds. One possibility is that when the S fails to find a perfect match in PM, there is some additional time spent in comparison of the two items before the decision is finally made that the items are indeed different. The lack of the Same-Different difference in RT for the Delay condition may reflect a difference in the coding process for PM and SM.

Another significant interaction was that of Category by Comparison Interval by Comparison Type, $F(2, 57) = 8.348$, $p < .001$. An important contribution to this interaction can be seen by considering the mean RTs for the Same comparisons. The difference between mean RTs for Word and E-Pr is much larger in the case of delayed comparisons than it is for the case of immediate comparisons. The implication is that the semantic aspect of the material is more important for identification in SM than it is for identification in PM. Put another way, the semantic cue is a more important feature of the memory code in SM than it is in PM. In PM, the physical and phonological aspects of the item may be relatively more important.

Experiment II

Experiment II represented an emperical approach to the very old problem of word meaning. The point of view adopted was that a verbal item has meaning if it can be referenced in the person's memory, that is, if it has a "semantic tag." The major question of interest in Experiment II concerned the type of information a person uses in

Table 1

Means and Standard Deviations of Reaction Times

to Verbal Items under All Subconditions

Category		Task			
		Immediate		Delay	
	Same		Different	Same	Different
Word	Mean	.765	.901	1.026	1.063
	SD	.208	.154	.233	.206
E-Pr	Mean	.806	.988	1.163	1.134
	SD	.178	.190	.227	.241
D-Pr	Mean	.862	1.008	1.100	1.133
	SD	.231	.218	.302	.247

referencing items in his memory. The meaning of an item is not established until a person locates a semantic tag; what features of verbal items determine how quickly the identification process takes place? The S's basic task was simply to look at a verbal item and to decide as quickly as possible whether or not the item was a member of his vocabulary. Everyday observation indicates that people can decide very rapidly whether or not some item has a semantic tag in their memory. Consider the example of the skilled reader encountering an item such as "mantiness." Despite the item's legitimate phonological construction, the reader knows almost immediately that it does not have a semantic tag. The extreme rapidity of the process implies some highly efficient mechanism by means of which the number of memory items which are being searched can be restricted since it seems quite inconceivable that a person matches a presented item against all vocabulary items in his memory. In the present experiment the phonological and semantic characteristics of the material were manipulated to determine what role, if any, these variables had on the speed of the referencing process.

Subjects - The Ss were 20 undergraduate students at Oklahoma State University who were paid $1.50 per session for each of two sessions.

Materials - The materials were constructed by means of the Venezky (1962) norms which is an extensive table showing the frequency of grapheme-phoneme combinations in a large sample of English words. Sets of four CVC syllables were constructed by forming all combinations of relatively high-and relatively low-frequency initial and final consonants. An example of a set of CVCs in the order high-high (HH) high-low (HL), low-high (LH), low-low (LL) is as follows: SUT, SUX, WUT, WUX. Associated with each set of CVCs were control sets of words and CCCs. Counterparts to the foregoing set of CVCs would be for words, SAT, SIX, WET, WAX; and for CCs, SVT, SJX, WKT, WLX. High frequency consonant combinations were avoided in the construction of the CCCs. Seventeen sets of each category were constructed. A set of filler words similar in construction to the control words were included so that the materials would contain one-half words and one-half nonwords. Forty items composed of words, CVCs, and CCCs were constructed to be used as practice materials.

Procedure - The same apparatus was used as in Experiment I. Each trial was preceded by a buzzer which signalled the S to attend to the Plexiglas screen. A few seconds after the buzzer an item was presented to which S was to respond as quickly as possible indicating whether the item was or was not in his vocabulary. The response was the movement of a toggle-type switch, and the time from the onset of the item until the switch movement was recorded to the nearest millisecond. The intertrial interval was 10-15 seconds.

The Ss participated for two consecutive days for sessions of approximately 50 minutes. The presentation order of the items was random with the restriction that an equal number of words, CVCs, and CCCs occur on each day. The items occurring on the first and second days were counterbalanced between Ss. A practice session consisting of the same 40 practice items preceded each of the experimental sessions.

Results and discussion - A score for a given individual in a given subcondition is the mean of the RTs to the items comprising that subcondition. In most cases there were 17 RTs contributing to the mean, but some errors did occur when Ss accepted a word or rejected a non-word. In no case was there fewer than 14 RTs on which to base the score. The means and standard deviations of the scores over 20 Ss are presented in Table 2. The scores were subjected to a 3-factor analysis of variance in which all factors (Category, First Letter frequency, Third Letter frequency) were within Ss. All effects which did not meet or surpass the .05 level of significance were considered satistically nonsignificant.

The only significant main effect was that of Category, $F(2, 38) = 51.948$, $p < .001$. A very large overall difference (251 msec.) appears between CVCs and the CCCs which were matched on the first and last letters. The presence of the vowel appears to be a very important feature in determining the word status of a letter string. Apparently the memory search can be terminated much more quickly for the CCCs than for the CVCs.

A substantial difference (131 msec.) appears between the overall RT means for CVCs and words; CVCs take considerably longer to reject than words do to accept. The results are consistent with the idea that once the structural information in an item has been processed, there is a continuing search for a semantic tag. When the tag is located in the case of words, the processing stops and the decision is made. In the case of the CVCs, the S must exhaust the portion of memory to which he has been restricted by the structural information.

Both the Category by First Letter frequency interaction effect and the Category by Third Letter frequency interaction were statistically significant. The F values were respectively, $F(2, 38) = 7.871$, $p < .005$ and $F(2, 38) = 25.904$, $p < .001$. The effect of First Letter and Third Letter frequency is different depending on the category.

A different pattern in the 2-factor interactions is indicated by the significant 3-factor interaction of Category by First Letter by Last Letter; $F(2,38) = 6.308$, $p < .005$. There appears to be no difference in RT attributable to frequency of first or third letter for the CCCs. By contrast, both first and third letter frequency seems to affect RT for CVCs. To pursue the hypothesis suggested for the comparison between CVCs and words, it may be that there is simply more memory to search in the case of CVCs having high frequency initial and terminal phonemes. However, the decision to reject CCCs as vocabulary items apparently can be made independently of phoneme frequency.

The direction of the interaction between first and third letter frequency for Words is opposite to that for CVCs; Search time is approximately 90 msec. shorter for HH than for the other frequency combinations. This result implies that there is something more to the search process than simply the size of the memory area which has been restricted by the structural information in the item, since, when there is a semantic tag for the item, high frequency facilitates rather than hinders search speed. A purely speculative but plausible hypothesis

Table 2

Means and Standard Deviations of Reaction Times to Verbal Items under All Subconditions

		Frequency			
		First Letter			
		High		Low	
Category		Third Letter		Third Letter	
		High	Low	High	Low
CVC	Mean	.931	.848	.870	.840
	SD	.305	.208	.251	.234
Word	Mean	.679	.769	.757	.762
	SD	.157	.200	.240	.204
CCC	Mean	.609	.603	.609	.613
	SD	.108	.116	.124	.130

is that semantic tags are ordered according to frequency of usage within memory areas which are indexed by structural information.

General Conclusions

Both experiments demonstrated quite clearly that both phonological and semantic variables had an influence on identification speed for verbal material. The most important single finding in the first experiment was that the semantic cue had a much larger influence on speed of identification when material was in SM or long-term memory as compared to the case when the material was in PM or short-term memory.

Experiment II is most likely the more important one from the point of view of reading research. The experimental task appears to be a much better analog of at least part of what the reader does than those which have been used previously. The results were very informative in showing the separate contributions to identification speed of the structural (visual, phonological, etc.) information and the semantic information. Further experimentation using the present methodology with more complex materials appears to be quite promising.

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